Region 9 Perchlorate Update

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The U.S. Environmental Protection Agency (EPA) has been working in partnership with states, federal agencies, tribes, water suppliers and the private sector to address a recently discovered threat to water supplies from a component of solid rocket fuel and other sources. The Interagency Perchlorate Steering Committee (IPSC) is co-chaired by the EPA and the Department of Defense (DoD) and is comprised of representatives from 19 state, federal, and tribal agencies.

Background

Perchlorate originates as a contaminant in the environment from the solid salts of ammonium, potassium, or sodium perchlorate. The perchlorate part of the salts are quite soluble in water. The resultant anion (ClO_4^-) is very mobile in aqueous systems. It can persist for many decades under typical groundwater and surface water conditions, because of its resistance to react with other available constituents.

Ammonium perchlorate is manufactured for use as the oxidizer component and primary ingredient in solid propellant for rockets, missiles, and fireworks.

Large-scale production began in the United States in the mid-1940s. Because of its shelf life, it must be periodically washed out of the country's missile and rocket inventory and replaced with a fresh supply. Thus, large volumes of the compound have been disposed of since the 1940s in Nevada, California, Utah, and likely other states. Perchlorate salts are used on a large scale as a component of air bag inflators. Ammonium perchlorate is used in the manufacture of matches and in analytical chemistry.

Other uses of perchlorate salts include their use in nuclear reactors and electronic tubes, as additives in lubricating oils, in tanning and finishing leather, as a fixer for fabrics and dyes, in electroplating, in aluminum refining, in rubber manufacture, and in the production of paints and enamels. Chemical fertilizer also has been reported to be a potential source of perchlorate contamination.

The EPA had established a provisional reference dose (RfD) range based on assessments of existing information in 1992 and revised in 1995. By applying the standard default body weight (70 kg) and water consumption level (2 L/day), the resulting provisional cleanup or action levels would range from 4-18 parts per billion (ppb).

Prior to April 1997, perchlorate could not be detected at concentrations below 100 ppb. Many uncertainties remained about its toxicity, about how to remove it from water, or how extensive a problem perchlorate might pose to water supplies. In April 1997, the California Department of Health Services (CA DHS) developed a new analytical method to detect low levels of perchlorate (4ppb) in water. Within the last two years, this chemical has been found in the water supplies of over 15 million people in CA, NV and AZ and in surface or groundwater throughout the United States (AR, IA, IN, KS, MD, NM, NY, PA, TX, UT, WV).

Perchlorate is of concern because of: 1) Potential health effects at low concentrations; 2) the possibility that perchlorate may be widespread in the environment; 3) the expense of removing perchlorate from water and soil; and 4) the effects that perchlorate may have on ecosystems.

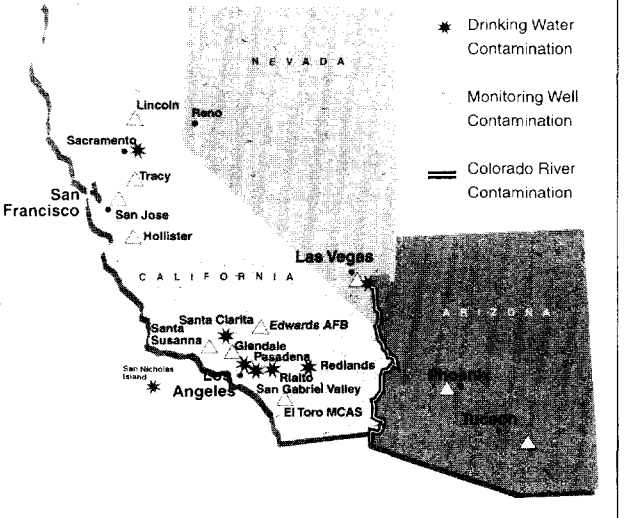
Research has been carried out at an accelerated pace to better understand the human health effects of perchlorate, examine possible ecological impacts, refine analytical methods, develop treatment technologies, and increase occurrence data, while keeping stakeholders informed and involved.

Toxicology

The EPA held an external peer review of the document entitled "Perchlorate Environmental Contamination: Toxicology Review and Risk Characterization" on February 10-11, 1999 in San Bernardino, CA which was open to the public. The external review document (ERD), was developed by the EPA's Office of Research and Development, National Center for Environmental Assessment (ORD/NCEA). The ERD presented an updated human health risk assessment as well as a screening-level ecological assessment of newly performed studies on the toxicity of perchlorate. The updated human health risk assessment model harmonizes noncancer and cancer approaches to derive a single oral risk benchmark for perchlorate. The proposed revised oral human health risk benchmark is 0.0009mg/kg-day. The proposed revised oral risk benchmark is an estimate of the amount of perchlorate, which when ingested daily over a lifetime is anticipated to be without adverse health effects (both noncancer and cancer) to humans, including sensitive subpopulations. Finalizing the oral risk benchmark requires completion of additional toxicology studies and further evaluation of toxicology results.

The EPA has committed to another external peer review as part of the process to more completely and accurately characterize the human and ecotoxicological risks associated with perchlorate contamination. In the next assessment, NCEA will address comments

Figure 1: Perchlorate Occurrences in EPA Region 9



made in the external peer review report, as well as review and incorporate data from additional studies that were either nearing completion or recommended at that time. The purpose of the next external peer review will be to evaluate these additional data and to review the final draft NCEA assessment on perchlorate. All of the perchlorate testing and study activities, whether underway, in review, or planned, are being timed to support the goal of the next external peer review in early 2000.

Because new analyses and data are to be considered, the human and ecotoxicology benchmarks are likely to change. The new estimates will reflect greater accuracy and may be either higher or lower than the harmonized benchmark proposed in the ERD. The Office of Research and Development has recommended that the EPA's risk assessors and risk managers continue to use the standing provisional reference dose (RfD) range of 0.0001 to 0.0005 mg/kg-day because of continued uncertainty with respect to the impact of the pending data and analyses. This recommendation helps to ensure that the EPA bases its risk management decisions on the best available peer reviewed science and is in keeping with the full and open participatory process of the series of external peer review workshops. The standing provisional RfD range is the more conservative of the estimates available at this time and, therefore, more likely to be protective of public health. This is also consistent with the EPA's practice that existing toxicity estimates remain in effect until the review process to revise them is completed.

Regulatory/Federal

There is currently no federal National Primary Drinking Water Regulation for perchlorate. It is on the EPA's Safe Drinking Water Act's Contaminant Candidate List, but before a determination to regulate can be made, data gaps must be filled regarding occurrence, health effects, treatment technologies, and analytical methods. Finding these answers for perchlorate is a very high priority.

Following the establishment of a final harmonized oral human health risk benchmark for perchlorate, the EPA will develop a drinking water Health Advisory. Based on the current proposed revised oral risk benchmark, and standard default body weight (70 kg) and water consumption (2 L/day) values, a drinking water equivalent level (DWEL) would be calculated at 31.5 ppb. It is important to recognize that the DWEL is a level that assumes all perchlorate exposure comes from drinking water and does not take into account the contribution of perchlorate from other sources, which will be considered in developing a Health Advisory.

Regulatory/States

In 1997, California established an action level of 18 ppb for perchlorate in public water supplies. Legislative action to establish a state drinking water standard for perchlorate was passed in 1998 (CA Senate Bill 1033) but was vetoed by the governor. In January 1999, CA DHS adopted a regulation identifying perchlorate as an unregulated chemical for which monitoring is required. Certain drinking water systems will need to sample their drinking water sources for perchlorate.

In August 1997, the Nevada Division of Environmental Protection (NDEP) selected 18 ppb as the recommended action level for cleanup pending a more current risk assessment.

In March 1999, the Arizona Department of Health Services set a provisional Health Based Guidance Level of 31 ppb.

Texas has decided to use 32 ppb as an "interim" action level for perchlorate in drinking water.

No other state is known to have adopted action levels for perchlorate.

Figure 2: States With Identified Perchlorate Manufacturers or Users

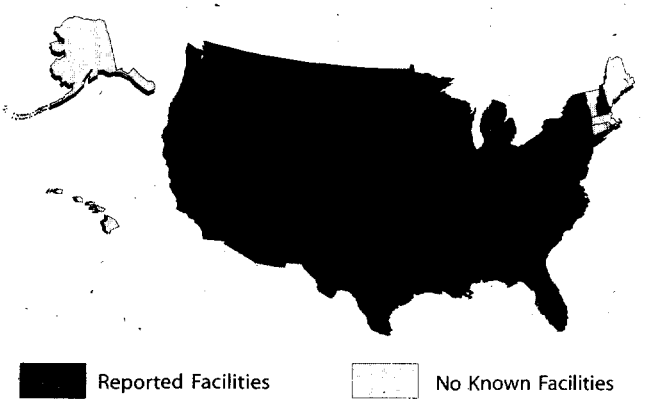
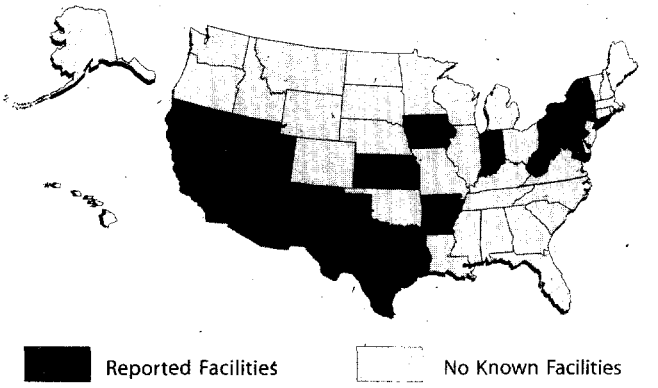


Figure 3: States with Environmental Releases of Perchlorate



Colorado River

Perchlorate concentrations at the Metropolitan Water District's (MWD) water intake at Lake Havasu, CA have averaged 6 ppb for the last two years (range 5 to 9 ppb). Arizona's Central Arizona Project (CAP) also takes water from Lake Havasu. Perchlorate concentrations in Lake Mead, at the water intake for the city of Las Vegas, have varied from less than 4 ppb to 16 ppb. The EPA is working with the NDEP to clean up the source of the perchlorate in Henderson, NV, and is monitoring the river for perchlorate in collaboration with the U.S. Geological Survey, adjacent states and other agencies.

Groundwater

In California, 140 public water supply wells have reported perchlorate above 4 ppb. Water suppliers have shut down wells or blended water so that they are providing water which does not exceed the California action level of 18ppb. In EPA Region 9, we know of 19 separate releases of perchlorate to the environment affecting 3 states, 11 tribes and perhaps Mexico.

Treatment Technologies

In the two years since perchlorate was discovered in water supplies in California, Nevada, and Arizona, much progress has been made in developing treatment methods capable of removing perchlorate from water. Most of the attention has been directed at two technologies: biological treatment and ion exchange.

Biological Treatment

In the biological treatment process, microbes destroy perchlorate by converting the perchlorate ion to oxygen and chloride. In most cases,

nutrients must be added to sustain the microbes. A six month pilot-scale study of a biological process has been completed for the San Gabriel Valley Superfund Sites, demonstrating the reduction of perchlorate from approximately 75 ppb to below detectable levels. The same process is being used in a recently-constructed full-scale system at the Aerojet Superfund Site in Northern California, where perchlorate concentrations exceed 1,000 ppb. A biological process has also been used to treat perchlorate-contaminated wastewaters resulting from the manufacture and maintenance of rocket motors, where perchlorate concentrations may exceed 500,000 ppb.

Biological treatment methods are believed to be capable of producing potable water, but additional testing must be completed to determine whether a biological process can reliably and cost-effectively produce drinking water quality water. The necessary tests are planned for later this year, when a 500 gallon per minute biological treatment system designed to produce potable water for use in the San Gabriel Valley should be in operation. The treatment system is expected to include a biological reactor, followed by a biologically-active multimedia filter and granular activated carbon (GAC) polishing treatment. Biological treatment methods are new to many water utilities, but biologically-active filters have been used in drinking water treatment for decades to help remove particles and biodegradable organic matter. The treatment train to be used in the San Gabriel Valley project will rely on biological treatment for primary removal of perchlorate, and is expected to include GAC as a backup process capable of limited perchlorate removal.

Ion Exchange

The second of the two perchlorate-removal technologies receiving the most attention is ion exchange, in which the perchlorate ion is replaced by chloride, a chemically similar but nontoxic ion. Ion exchange processes have been used in homes and businesses for water softening for decades. Bench-and pilot-scale studies have demonstrated that ion exchange systems can reliably reduce perchlorate concentrations in San Gabriel Valley groundwater from approximately 75 ppb to below detectable levels. The studies have also provided valuable information on resin selection and regeneration, brine production, and cost that will guide the design and operation of full scale systems. By Summer 1999, a 2500 gallon per minute ion exchange system is expected to be online producing potable water for use in the San Gabriel Valley.

The principal disadvantage of ion exchange systems is that they produce a concentrated brine that requires disposal and/or further treatment. Research is underway to try to identify methods of reducing the volume of perchlorate-contaminated brines to reduce the high cost of disposal.

Two other technologies have also been demonstrated capable of removing perchlorate, but probably at higher cost. Reverse osmosis and nanofiltration were tested by researchers at the Metropolitan Water District of Southern California and shown to be effective in removing perchlorate, but they are likely to be much more expensive to operate than ion exchange processes. Liquid phase GAC also removes perchlorate, but only for a limited period of time before regeneration or replacement of the carbon is required. Frequent carbon replacement would make relying solely on GAC for perchlorate removal very expensive. Perchlorate cannot be removed from water by conventional filtration, sedimentation, or air stripping technologies.

In the next two years, the results of perchlorate treatment research funded by a $2 million Federal appropriation to the American Water Works Association Research Foundation (AWWARF) will be available. AWWARF is funding studies into biological treatment methods, ion exchange, reverse osmosis, nanofiltration, and other processes. The results of the AWWARF research should allow more efficient design and operation of ion exchange and biological treatment processes, and may identify other technologies capable of more cost-effectively removing perchlorate from water.

The "best" technology for removal of perchlorate will probably vary from site to site. By the end of 1999, it is likely that full scale ion exchange and biological treatment systems will have been constructed and begun operation, providing cost and performance data that will be available to help others choose the best technology for their site. The results from recent and ongoing studies will be of use to water utilities in need of reliable, easy-to-operate treatment methods that can reliably reduce perchlorate concentrations to low or non-detectable levels, and in the remediation of non-potable contaminated groundwaters.

Analytical Issues

Ion chromatography (IC) is the state-of-the-art analytical method for the measurement of perchlorate in water. Federal, state, and private laboratories collaborated to study the existing IC method and its variations. The study design evaluated the within laboratory precision (repeatability), between laboratory precision (reproducibility), method accuracy (bias), detection limit, and sensitivity of the method. The results of this collaborative study will help focus future research and method development.

An increasing number of commercial and government laboratories are capable of low level perchlorate analysis, leading to further discoveries of perchlorate contamination. Development of a formal published method documenting the reproducibility and limitations of the technique is expected to facilitate the acceptance of perchlorate testing at low concentrations by laboratories across the country. The need for a reporting limit of 4 ppb taxes the sensitivity and reproducibility of the current IC method. Work is also being planned to develop different analytical techniques to confirm the results of the IC method.

Interagency Perchlorate Steering Committee (IPSC)

The Interagency Perchlorate Steering Committee (IPSC) was formed in January 1998 and now has representatives from 19 different government agencies. Its purpose is to ensure an integrated approach to addressing perchlorate issues and to inform and involve stakeholders about developments in the technical and regulatory arenas. Four EPA representatives serve on the Executive Committee of the IPSC and EPA representatives serve on all of the subcommittees of the IPSC (health effects/toxicity, ecological impacts/transport and transformation, occurrence, treatment technology, analytical, communications and outreach, and external peer review). The initial toxicological assessment effort for perchlorate was accomplished in an extraordinarily expedited time frame through the partnership of the IPSC membership.

As of June 1999, the following agencies are members of the IPSC: U.S. Environmental Protection Agency, Department of Defense, Agency for Toxic Substances and Disease Registry, National Institute for Environmental Health Sciences, National Aeronautics & Space Administration, Bureau of Indian Affairs, Arizona Department of Environmental Quality, Arizona Department of Health Services, California Department of Health Services, National Park Service, Nevada Division of Environmental Protection, Texas Natural Resource Conservation Commission, Utah Department of Environmental Quality, Utah Department of Health Laboratories, Cocopah Tribe, Colorado River Indian Tribes, Fort Mojave Tribe, Chemehuevi Tribe, Quechan Tribe.

U.S. Environmental Protection Agency World Wide Web Sites

EPA Perchlorate Web site:
http://www.epa.gov/ogwdw/ccl/perchlor/perchlo.html

NCEA External Review Document:
http://www.epa.gov/ncea/perch.htm

Other Region 9 World Wide Web Sites

California Department of Health Services:
http://www.dhs.cahwnet.gov/ps/ddwem/chemicals/perchl/perchlindex.htm

Arizona Department of Environmental Quality:
http://www.adeq.state.az.us

Nevada Division of Environmental Protection:
http://www.state.nv.us/ndep/

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A number of documents related to perchlorate are indexed and available from the EPA's Region 9 Superfund Records Center, located at 95 Hawthorne Street in San Francisco, CA. The Superfund Records Center is open from 8:00 a.m. to 5:00p.m., Monday through Friday. For more information on document availability, contact the Superfund Records Center at 415-536-2000 or Catherine McCracken at 415-744-2182 or 800-231-3075 (toll-free from AZ, CA, HI, NV, and the U.S. Territories only).

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